NEWS REPORT

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NEWS REPORT

National Academy of Sciences National Research Council

VOLUME VII *January–February 1957* NUMBER 1

Thirteen Years of Ship Structure Research

DAVID K. FELBECK, *Executive Director*

Committee on Ship Steel and Committee on Ship Structural Design

WHEN the steel hulls of welded merchant ships began breaking up by brittle fracture at an alarming rate in the early part of World War II, a Board of Investigation was established by the Secretary of the Navy to inquire into the causes of these failures, which usually occurred with almost explosive suddenness. Thus began a ship structure research program that has continued to the present time under essentially the same sponsorship. In 1946, in accordance with a recommendation of the wartime Board of Investigation, the Secretary of the Treasury established the Ship Structure Committee to continue on a permanent basis studies directed toward improvement of the hull structures of ships. The Ship Structure Committee, like its wartime predecessor, was composed of representatives of the U. S. Coast Guard, the Bureau of Ships and Military Sea Transportation Service of the U. S. Department of the Navy, the Maritime Administration, and the American Bureau of Shipping.

The parent organization is perhaps the only part of this program that has not changed since its inception. The mechanism for guiding and administering these investigations in the early days consisted of liaison between the Board of Investigation and members of the War Metallurgy Committee of the National Academy of Sciences–National Research Council. After establishment of the present Ship Structure Committee, the program passed through several stages of evolution with respect to the advisory and administrative services sought from the Academy–Research Council. The Committee on Ship Construction was first organized by the Academy–Research Council to advise on certain specific problems and projects; later the committee was reorganized as the Committee on Ship Steel with responsibility for advisory and administrative services in all materials research activities. The entire program later came to be regarded as divided into three distinct phases: *1*) Materials, advised by the Committee on Ship Steel; *2*) design, advised by the newly created Committee on Ship Structural Design; and *3*) fabrication, advised by the Ship Structure Subcommittee, the working arm of the Ship Structure Committee, which in turn was the inter-agency governmental body responsible for the over-all program. During one period the Academy–Research Council established a Committee on Residual Stresses to prepare a special monograph on the part played by residual stresses in the performance of various kinds of structures, with particular emphasis on their possible contribution to brittle failures.

As the organization of this work became refined and as the large mass of results from the urgent wartime research program

began to be digested, the direction and methods of research began to follow new paths. The discussion that follows is an examination of the program from its inception under heavy pressure to fulfill immediate needs, through the idealistic phase when it was believed that much could be solved by "pure" research in often unrelated subjects, to the present understanding of the requirements for both rigorous, applied studies and thorough, related fundamental research. This last stage should be able to provide reliable answers to current specific problems while pursuing vigorously at the same time the little-understood fundamentals that must be brought to light if any long-term advances are to be expected.

Needs and Solutions of the Wartime Program

Someone had to find ways to prevent welded ships from breaking in two. This became crystal clear when the T-2 tanker *Schenectady* broke in two in calm water at her fitting-out dock on January 16, 1943. The purpose of the Board of Investigation was to take effective measures to reduce or eliminate fractures that could endanger a ship's structure. In such an emergency, any investigation had to be capable of producing quick answers. We tend to forget today how little was known about the brittle-fracture phenomenon at that time, although it had been observed in non-ship structures for more than 50 years and in riveted ships almost as long.

One of the most conspicuous structural defects was the square hatch corner on the Liberty ship, where 25 percent of all early fractures originated. Full scale experiments on modified hatch corners demonstrated that hatches with rounded corners and more gradual changes in cross section near the corners could absorb far more energy before failure than the original design. This improved energy absorption was attributed to the ability of the modified design to yield plastically in critical regions. Similar developments on the T-2 tanker led to a 40 percent reduction in the stress concentration at certain locations on the longitudinal bulkheads through use of reinforcing brackets.

In addition to design deficiencies, fabrication techniques were suspected of contributing to brittle fracture. Investigation showed that residual stresses up to 47,000 pounds per square inch occurred in welded ship structures. Nevertheless, in its *Final Report . . . to Inquire into the Design and Methods of Construction of Welded Steel Merchant Vessels* (Washington, D. C., 1946), the Board concluded that these stresses did not contribute materially to failure, and little more was done about it.

Other fabrication faults such as flaws and notches were believed to contribute to failure because all fractures investigated originated at a notch or other discontinuity. All that could be recommended at the time to reduce the danger from flaws was to improve welding and inspection methods; this improvement is still going on.

The fact most surprising to us today is that prior to formation of the Board it was not generally realized that the transition temperature of ship steel (i.e., the temperature below which a steel is relatively brittle in a fracture test), as measured by impact tests in use at the time, was within the range of ambient and failure temperatures. The first step of the Board was thus to establish that a materials problem actually existed! Once this was done, the search began for a small-scale test that would accurately predict service performance of large structures. Many geometrical configurations were tried with variations in size, method of loading, notch severity, and criterion for evaluation. The several methods that were in use did give some idea of the quality of steels and were probably satisfactory for urgent wartime needs. However, for the sake of future investigators faced with problems of similar complexity, it should be noted that 13 years of desultory testing have shown that, while a few tests give fair correlation with service experience for particular kinds of steel, no single test has yet been demonstrated to have general utility. It has become clearer that except for chance discovery of the right combination of variables the only way to develop a satisfactory test is through better understanding of the fundamental mechanisms governing fracture.

On the basis of rough early studies, the

Board concluded that the current specifications were inadequate to assure safety from brittle fracture. The Board also thought it necessary to report that the three gradations in steel melting practice produced plate of increasing quality, ranging from the poor "rimmed" steel to better "semi-killed" steel, to the best "killed" steel. It can thus be seen that facts well known today may not have been understood even a few years ago by very many people.

The earliest efforts of the Board were directed toward bringing the most pressing problems into focus. This was not easy. The Board was led up some blind alleys, such as the ductility test, and even reached some conclusions that may have been wrong, such as its statement regarding residual stresses. Nevertheless, the Board was able to achieve its major goal—the reduction of the ship casualty rate—through methods that were almost entirely empirical. The success of the Board through such unrefined techniques may be attributed in part to the general ignorance regarding the dangers of brittle fracture in welded ships. Marked improvement was possible because the situation was so bad.

Postwar Orientation

The great success of the wartime program of empiricism made the work of the Board's permanent successor, the Ship Structure Committee, even harder. The major casualty rate for Liberty ships by 1948 was reduced from about 6 per 100 ship-years for the all-welded vessel to 0.22 for vessels with improved hatches and riveted shell seams. By 1950, the major failure rate of T-2 tankers was reduced from about 8 per 100 ship-years to 0.7 by some changes in design and the introduction of crack arrestors. Further reductions could not possibly appear as spectacular and would certainly be more difficult to achieve.

During these years of transition from immediate wartime demands to longer-term peacetime problems, the Ship Structure Committee began to find that further refinements were needed. Small energy-transition tests were found to be inadequate, because they could not discriminate between two steels with similar properties as well as wide-plate tests could. Investigators worried about the problem of increasing transition temperature with increasing plate thickness, a phenomenon that is becoming even more important today as larger ships, particularly tankers, are being built. The crack arrestor, which had aided in the relatively large reduction of wartime casualties, was found upon closer examination to be undependable in stopping a running crack. Local panel bending was found to be less in riveted ships than in welded ships. These new problems, which arose from a better understanding of factors contributing to ship failure, led the Ship Structure Committee to a permanent, organized program of ship research. At a time when the whole idea of Government-sponsored merchant ship research might have been dropped, a few men with vision and determination carried the work forward.

There were concrete achievements, too. In part as a result of work under the Board of Investigation and the Ship Structure Committee, the American Bureau of Shipping (ABS) in 1947 established a steel-making and composition specification for the steel used in merchant ships under its classification. No ship built to these requirements has had a serious structural failure in the nine years since then. In late 1955, on the basis of some failures on ships built to other specifications close to the ABS Rules, and again in part as a result of the Ship Structure Committee's research on the effect of composition, the ABS Rules were further refined.

In taking a long look at the problems ahead, there were times when the look was perhaps too long and the view too dim. Several disconnected studies were initiated in fields that were rather remote from ship problems, although the projects by themselves were well done and contributed to the general fund of knowledge. One example is an investigation of flow and fracture of single crystals of a non-ferrous material. This showed the importance of the twinning mechanism for this material; but since twinning is now generally considered to be unimportant in the fracture of mild steel, this part of the investigation

did not contribute significantly to the problem of ship steel.

An example of a useful applied study is the work that was done on the influence of composition and deoxidation practice on impact properties of steels. A series of laboratory heats of varying composition were manufactured under conditions closely simulating commercial production. The major conclusions showed that the transition temperature would be reduced (improved) by increase of manganese, decrease of carbon, phosphorus, nitrogen and, within limits, increase of silicon. Rolling-mill studies demonstrated the possibility of further improvement through lowering of plate temperature before the last few passes in the mill. This research program has pointed the way to several other developments, including current manufacture of some full scale commercial heats of high-manganese low-carbon steel for use in ships, and to further studies of the influence of mill rolling temperatures on metallurgical structure.

Another project that bore immediate fruit was the series of tests on details of the intersection between a bottom longitudinal and a transverse bulkhead. These tests showed that the through logitudinal (a continuous beam fitted through the bulkhead) absorbed 16 times the energy absorbed by the interrupted longitudinal as originally designed for the T-2 tanker. Tankers incorporating this new design have been built and are operating successfully.

Several other programs during this period could be used to demonstrate the value of a mixture of fundamental and empirical studies. The important fact to recognize is the desultory nature of the total program; while the methods were more refined, the scope of the program was not well defined. Some problems were obvious and thus received attention. Other problems, particularly those of a fundamental nature, were less obvious and so were often neglected. Several reports of a survey or interpretive nature helped to pin down the need for answers in certain areas and thus served to bring the research program of the Ship Structure Committee into its present position.

The Next Ten Years

Out of the experience of over a decade of research a workable system of administration has evolved. The number of government groups involved and the extent to which they participate in and influence daily decisions sometimes create real problems of administration and operation. But the important fact is that the mechanism works. The Ship Structure Committee maintains responsible control and direction over the entire program through annual meetings and frequent consultation by each individual member with his agency's representatives on the Ship Structure Subcommittee. This subcommittee serves as the working arm of the main committee, as noted earlier. It meets about five times each year, maintaining close contact with the total research program, and also directly advises research in the field of fabrication. The Academy–Research Council's Committees on Ship Steel and on Ship Structural Design provide advisory guidance and general administration for the materials and design research programs, respectively. It is through the good relations that exist among these several groups and the desire of all concerned to promote an effective program that this rather sprawling system of control can work. The advantages are that each agency can know at all times what is going on, and also that the large number of interested members provides the research program with the advice of a broad spectrum of professional experience. The disadvantages are that even though one group of specialists may be able to see clearly the need for study in a particular region, it is sometimes difficult to convince other groups not so well informed. However, this is the essence of diversified control, and it has great strength so long as each group will also assume the responsibility that should accompany such control.

The next ten years should see the growth of the fundamental ship design program of the Ship Structure Committee. Developments of the past decade in seaway analysis and wave prediction indicate that the seaway forces acting on a ship may soon be known with much better accuracy. This

means that the fundamentals of structural design can come into general use in ship design for the first time. The complexity of a hull structure, combined with the little-understood character of waves, has in the past dampened enthusiasm for application of these fundamental methods to ship design. A survey report is being completed covering research to date on waves, hydrodynamic forces, dynamic ship response, and resultant stresses in the ship. A thorough planning of the desired sequence for needed research in this design field will soon be initiated by a competent group. Inquiries are already being received regarding initiation of individual research projects. In cooperation with other professional societies, the Ship Structure Committee is entering an almost untouched area. Studies will be needed on models, analyses will point toward better design, and tests on ships at sea will give solid strength to the whole program. It is necessary that a group with the history and development of the Ship Structure Committee be able to provide constant guidance to this work lest it drift back into a collection of disconnected projects as in the past.

Fundamental programs in the field of mechanics and mechanisms of fracture in mild steel are yielding new and valuable facts. It is now known, for instance, that during crack propagation a transient strain wave with a peak value of more than three times yield strain traverses the specimen. Another study has shown that even at low temperatures considerable plastic deformation occurs before a specimen reaches the yield stress. Better understanding exists regarding the relation between brittle fracture and the strain-hardening characteristics of steel at high strain rates. These results all stem directly from fundamental research of the Ship Structure Committee. Future work in these fields at the present rate should go far toward improving our knowledge of fracture and thus indicate clearly how to prevent fracture in ships most economically.

The Ship Structure Committee could not possibly carry out its research in the dark. One of its strongest assets is the large number of people interested in its work. Research workers both here and abroad have contributed much in the way of preventing duplication of research through their intimate knowledge of studies in progress and under consideration. Personal communications between Ship Structure Committee researchers and others outside the immediate program continue to provide two-way criticism and help. Informal exchanges of specimens provide experimental checks and additional evidence to separate groups working on related problems. The Ship Structure Committee should demand that its representatives know what is going on outside their own organizations, for it cannot afford to support much misdirected research.

The hard facts show the necessity for ship research. The entire cost of the Ship Structure Committee research program through 1956 was just under $3.5 million. This represents about one-half the cost of a merchant ship without cargo.

Within a framework of workable administration and combined with the acute need for knowledge in the several related fields, the Ship Structure Committee and its affiliated groups have at present a unique opportunity to set a high standard for research in the ship field. They have the interest and cooperation of some of the most competent engineers and scientists in the world in the fields of naval architecture, structural design, and materials and metallurgy. In a time of heavy demands on every technical person for his attention, this is a priceless asset. The Ship Structure Committee has built up a reputation with its investigators for sympathetic and rational cooperation. If the interest shown by many first-rate groups in recent research prospectuses of the Ship Structure Committee is typical, then the years ahead will be good.

THE ACADEMY'S PROGRAM FOR ESCAPEE HUNGARIAN SCHOLARS

In cooperation with President Eisenhower's Committee for Hungarian Refugee Relief, the National Academy of Sciences has established an office at Camp Kilmer, N. J., to help identify and place Hungarian scholars who have escaped from Hungary and sought safe haven in the United States. Up to the present time well over twenty thousand escapees have arrived by plane and ship. Many of these people have advanced scientific or other scholarly or professional training. A substantial percentage of those who have thus far arrived are graduates of the universities and technical institutes of Hungary and many have considerable professional competence.

On December 16, 1956, the Governing Board of the Academy–Research Council decided to make every effort to assist the Hungarian scholars who had found it necessary to leave their homeland. Three days later the Camp Kilmer office of the Academy was established under the joint direction of M. H. Trytten, Director of the Office of Scientific Personnel, and Wallace W. Atwood, Jr., Director of the Office of International Relations. Immediately thereafter escapees were being interviewed by a professional staff composed of leading scientists and educators from the universities of United States. In the weeks which have followed several hundred Hungarians have been interviewed and subsequently placement assistance has been given wherever possible. Many have been placed in positions in the universities, research institutions, and industrial laboratories of the country. The program is still under way.

One feature of the Academy's program which deserves special mention is the 8-week language and orientation course sponsored jointly by the Academy and Rutgers University. This special program was launched early in January when it became apparent that many of the escapees would need to learn English before they could accept positions commensurate with their professional training. The program is now well under way and the results are gratifying. All members of the group are expected to be placed by the Academy; many of them will receive fellowships to continue their graduate studies.

In this brief account of the Academy's program for Hungarian scholars, it would be remiss not to mention the cooperation which has been received from the scientific community of the United States. Requests for assistance have been graciously met, and universities and research institutions in large numbers have indicated a desire to accept and assist in the assimilation of the Hungarian scholars among the escapees.

INTERNATIONAL CONGRESS OF RADIATION BIOLOGY

An International Congress of Radiation Biology to be held in Burlington, Vt., August 10–16, 1958, is being organized under the joint auspices of the Subcommittee on Radiobiology of the Committee on Nuclear Science and the Radiation Research Society. Present plans contemplate a number of symposia by invited speakers on radiation physics, chemistry, radiobiology, radiation genetics, and studies on counteracting radiation damage, as well as contributed papers. Further details will be available early in 1957.

The membership of the organizing committee for the Congress is as follows:

ALEXANDER HOLLAENDER, Oak Ridge National Laboratory, *Chairman*
AUSTIN M. BRUES, Argonne National Laboratory
HOWARD J. CURTIS, Brookhaven National Laboratory
G. FAILLA, Columbia University
EDWIN J. HART, Argonne National Laboratory
A. K. SOLOMON, Harvard Medical College
RAYMOND E. ZIRKLE, University of Chicago

The Congress is being planned to dovetail with the International Genetics Congress which will be held in Montreal, August 20–28, 1958. The decision to hold the Congress of Radiation Biology was based on the information received from the United Nations that the Atoms for Peace Conference also scheduled for 1958 would not take place before September 1.

Inquiries concerning the Congress should be addressed to the Division of Physical Sciences, Academy–Research Council, Washington 25, D. C.

TERMINATION OF THE CHEMICAL-BIOLOGICAL COORDINATION CENTER

The Chemical-Biological Coordination Center, which has been a part of the Academy–Research Council for more than ten years, will terminate its activities within the next few months. The decision to close the Center was made after repeated efforts had failed to procure financial support sufficient to permit it to continue to operate effectively. The actual closing date will probably be about the end of June 1957.

The Center was established in 1946 to undertake on a large scale the accumulation of data and the development of techniques to permit the exploration by machine. methods of the broad relationships between chemical structure and biological activity. Within this general aim the work of the Center has included the development of a chemical and a biological code and associated coding procedures; the development of machine techniques; the design and supervision of a screening program for chemicals obtained from many sources; surveys of the literature of structure-activity relationships and of test methods; sponsorship of symposia on chemical-biological correlations; and abstracting and coding of specific reports on biological effects from past and current literature.

Those who founded the Center and gave it leadership as it evolved were convinced that a mechanized repository of chemical-biological information, able to carry on research on methodology, would become an invaluable bibliographic resource but, much more that that, would prove to be a powerful research tool for the discovery and exploration of correlations leading to important fundamental advances in the understanding of chemical-biological relationships and even of the nature of biological processes.

After a period of some four years devoted primarily to the development and refinement of the necessary codes and coding procedures, the intensive accumulation of data was undertaken. The Center has now coded on IBM cards more than 200,000 lines of biological data with reference to some 63,000 chemicals whose structures are coded in the files.

Through the years support for the Center has come from both inside and outside the Government. The Departments of the Army and the Navy, the National Institutes of Health, the American Cancer Society, the Atomic Energy Commission, and the National Science Foundation have all supported it, most of them over a period of several years. Budgets have shrunk, however, and support has declined accordingly. It has not proved possible to broaden the base of support sufficiently to maintain the level necessary for effective operation.

Careful review by qualified individuals and advisory committees from time to time has resulted in recommendations that every effort be made to continue the Center because of its great potential value to science. This conviction, however, has been coupled with the feeling that the Center should be discontinued if fully adequate support could not be obtained.

Walter Kirner, now Program Director for Chemistry at the National Science Foundation, was the Center's first Director. Having guided it through the development of its tools and techniques, he was succeeded in 1952 by Karl F. Heumann who directed the phase of building the Center's very great body of information and beginning to exploit it in the interests of science and scientists. Dr. Heumann left to take charge of a new research program of *Chemical Abstracts* in 1955 and George A. Livingston became Acting Director. Dr. Livingston is supervising the important work of getting the most that can be obtained from the Center's resources in the course of closing it out.

Chairman of the initial Advisory Committee that guided the Center's policies was Milton C. Winternitz. He was succeeded in 1950 by McKeen Cattell. In 1952 James G. Horsfall was apointed Chairman, and he has headed the Committee since that time.

A great deal of imagination and energy on the part of many people has gone into the development of the Center. It has embodied the vision of its leaders, staff, and sponsors. While it is a matter of the greatest regret that the Center must now be closed, there is no doubt but that its experience and achievements will stand as

significant milestones along the difficult way that science must move if the formidable problem of managing and using its vast accumulation of data is to be solved.

LECTURE BY HARLOW SHAPLEY

The third lecture in the Academy–Research Council series was delivered by Harlow Shapley, former Director of the Harvard Observatory and Paine Professor of Astronomy at Harvard University, on January 22. The title of the lecture was "Recent High Lights of Astronomical Research."

According to Dr. Shapley, so numerous are the recent highlights in astronomical research that the astronomical sky is one strong glow. The recent birth and rapid growth of radio astronomy merit first mention. Ten years ago the astronomers were hardly aware that signals of radio wave length were coming to the earth's surface from the sun, the planets, the exploding stars, the spiral structure of the galaxy, and the farthest reaches of the Metagalaxy. Now there are a dozen great radio telescopes, all larger than the Palomar glass mirror, built at great expense in England, Australia, Holland, Canada, West Germany, and the United States, and all devoted to the revelations that radio signals can provide. The largest American radio telescope with a mirror 140 feet in diameter is going to be built by the U. S. Government and mounted in West Virginia.

The establishment in South Africa of an international observatory incorporating Harvard's well-known Boyden Station is an important step in international cooperation. But the most important international operation in the history of science—the International Geophysical Year—also includes astronomical research. The artificial satellites will advance knowledge of celestial mechanics. The international study of the ionosphere will give us knowledge of earth-sun relationships. The antarctic meteors must be observed intently to settle a controversy; and the study of the movement of glaciers will provide information on the Ice Ages and the stability of solar radiation.

Among other highlights are:

1) The construction of several large reflecting telescopes and of two great coronagraphs in Colorado and New Mexico for the study of the sun.
2) The production of antiproton in the atom transformer at Berkeley and its implication of stars or even galaxies made of "anti-matter."
3) The discovery of star clusters that can properly be called intergalactic tramps.
4) The demonstration of the thermostating of the sun's radiation over an interval of nearly 2 billion years through the finding of blue-green algae in Archeozoic rocks.
5) The determination of the rate of expansion of the universe from the measures of the motions of 800 galaxies.
6) The development of convincing theories of the origin of the planetary system.
7) The proposal of "continuous creation" with an infinite past as a competitor with the "big bang" hypothesis of the creation of the universe with a finite past of only 5 to 10 billion years.
8) The emergence of varied evidence that the primeval atmosphere of the earth was free of oxygen, and that the origin of organisms had a natural beginning through the synthesis of amino acids and many other organic compounds as a by-play of lightning and ultraviolet light in an atmosphere of hydrogen gas, water, ammonia, and methane.

ANNOUNCEMENT OF FULBRIGHT COMPETITIONS

The Committee on International Exchange of Persons announces that the competition for 1958–59 Fulbright awards for university lecturing and postdoctoral research will be held from March 1 to April 15, 1957. Early in March the Committee will issue a booklet listing the awards for the following countries of Southeast Asia and the Pacific: Australia, Burma, Ceylon, India, New Zealand, The Philippines, and Thailand. At the same time the Committee expects to include awards for the following Latin America countries: Argentina, Chile, Ecuador, and Peru. There will also be announced a small number of 1956–57 awards under the recently negotiated Fulbright agreement with Israel. April 15, 1957, is the closing date for submitting applications for all programs.

Application forms and detailed programs may be obtained in March from the Conference Board of Associated Research Councils, Committee on International Exchange of Persons, 2101 Constitution Avenue, Washington 25, D. C.

NEW CHAIRMAN DIVISION OF ENGINEERING AND INDUSTRIAL RESEARCH

Edgar C. Bain, United States Steel Corporation, succeeded Clifford F. Rassweiler, Johns-Manville Corporation, as Chairman of the Division of Engineering and Industrial Research on January 1, 1957. Dr. Bain, a member of the Section of Engineering of the National Academy of Sciences, is a physicist, chemical engineer, metallurgist, and executive who has been associated with the research program of United States Steel since 1928. A graduate of Ohio State University, Dr. Bain also worked for B. F. Goodrich Company, General Electric Company, Atlas Steel Corporation, and Union Carbide and Carbon Company before joining United States Steel Corporation. The corporation's new fundamental research laboratory in Churchill Borough, Pittsburgh, is named for him, as is bainite, a metallographic constitutent of heat treated steels.

Among other awards Dr. Bain has received the Albert Sauveur achievement award of the American Society for Metals in 1946, the John Price Wetherill medal of the Franklin Institute in 1949, and the Grande Medaille of the Société Française de Metallurgie in 1952.

Dr. Rassweiler, who served a two-and-a-half-year term as Chairman of the Division, is now President-Elect of the American Chemical Society and will start his term of office in 1958.

HIGHWAY RESEARCH BOARD ANNUAL MEETING

The thirty-sixth annual meeting of the Highway Research Board, held in Washington January 7–11, attracted new record highs in both attendance and representation of participants. This is the second time the Board met outside the Academy–Research Council building in order to accommodate the 1,730 registrants attending the committee meetings and technical sessions.

Research workers from various state highway departments, universities and colleges, Federal agencies, trade associations, manufacturing companies, highway consulting groups, foundations, and local county and municipal highway departments presented 201 papers and reports in the course of the 38 technical sessions and the many committee meetings scheduled by the different departments of the Board. Staff members of 32 universities and colleges were responsible for 67 papers and reports. Research workers from 27 state highway departments prepared 55 papers. The remaining 79 presentations were made by 110 researchers from 58 different organizations. This represents an even wider range of participation than the previous record-breaking 35th annual meeting of the Board.

As one of the oldest continuing organizations of the Academy–Research Council the Board, established in 1920, serves as a clearinghouse for highway research information and this annual meeting provides an opportunity for scientists and engineers to present their findings to other experts working in the broad field of highway research. The papers read at the technical sessions ranged in subject from design and construction of roads to technical problems in soils and materials, traffic and vehicle operation, nighttime vision, and the important economic, psychological, and sociological problems of transportation and modern urban development.

One of the highlights of the meeting was the presentation of awards. This year the Roy W. Crum Distinguished Service Award was conferred upon Francis N. Hveem, Materials and Research Engineer, California Division of Highways. The Highways Research Board Award for the best technical paper delivered at the previous annual meeting was presented to Chester McDowell, Senior Soils Engineer, Texas Highway Department, for his paper on "Inter-Relationship of Load, Volume Change and Layer Thicknesses of Soils to the Behavior of Engineering Structures."

HIGHWAY RESEARCH BOARD EXECUTIVE COMMITTEE REORGANIZATION

In order to cope with the many new demands made upon the Highway Research Board, the Executive Committee of the Board has approved its reorganization and expansion in membership to a maximum of 19. This expansion will permit represen-

tation from the groups whose areas of interest lie in urban-metropolitan relationships, city and county roads, industrial research, and basic highway legislation.

The Executive Committee provided for rotation in office by having the Chairman serve a one-year term and by providing for a First and Second Vice Chairman also to serve one-year terms. The Chairman of the Executive Committee is also to be the Chairman of the Steering Committee. Upon completion of his term of office, the Chairman will serve two more years on the Executive Committee—one as Chairman of the Committee on Research Interpretation and Dissemination, and one as Chairman of the Ways and Means Committee.

The First and Second Vice Chairmen will also serve as Chairmen of the Committee on Publication Policies and of the Committee on Research Needs and Project Initiation, respectively. The Chairman of the Executive Committee will appoint the five standing committees mentioned above.

The present membership of the expanded Executive Committee is as follows:

REX M. WHITTON, Missouri State Highway Department, *Chairman*
C. H. SCHOLER, Kansas State College, *First Vice Chairman*
HARMER E. DAVIS, University of California at Berkeley, *Second Vice Chairman*
R. R. BARTELSMEYER, Illinois Division of Highways
J. E. BUCHANAN, University of Maryland
W. A. BUGGE, Washington State Highway Commission
DUKE W. DUNBAR, Attorney General of Colorado
FRANCIS V. DU PONT, Consultant, Parsons, Brinckerhoff, Hall and MacDonald, Inc.; and Lockwood, Kessler and Bartlett, Inc.
PYKE JOHNSON, Consultant, Automotive Safety Foundation
KEITH JONES, County Engineer of Jefferson County, Wash.
G. DONALD KENNEDY, Portland Cement Association
BURTON W. MARSH, American Automobile Association
GLENN C. RICHARDS, Commissioner, Detroit Department of Public Works
WILBUR S. SMITH, Wilbur Smith and Associates
K. B. WOODS, Purdue University
Ex officio:
C. D. CURTISS, Commissioner, U. S. Bureau of Public Roads
A. E. JOHNSON, American Association of State Highway Officials
LOUIS JORDAN, National Academy of Sciences—National Research Council

GEOGRAPHIC FIELD RESEARCH

The Screening Committee of the Division of Earth Sciences met on December 8 to evaluate the proposals for geographical field research in foreign areas received under the program sponsored by the Office of Naval Research. Of the 19 proposals submitted the following seven were selected for support:

Weston Blake, Jr., Geomorphological studies in North East Land, Svalbard—20 months
Clinton R. Edwards, Local water-borne transport and economy of the west coast of South America—12 months
Aloys A. Michel, Helmand Valley Project of Afganistan—12 months
George N. Nasse, Effect of land reforms on southern Italy—6 months
Herbert L. Slutsky, Protein malnutrition in Guatemala—7 months
Norman L. Stewart, Cultural geography in eastern Paraguay—13 months
Leonard Tow, Southern Rhodesia's manufacturing economy—12 months.

Richard J. Russell, Past chairman of the Division, presided and the other members of the Committee were: Meredith F. Burrill, U. S. Department of the Interior; Charles B. Hitchcock, American Geographical Society, and John A. Morrison, geographic consultant of Quincy, Ill. The foreign field research program is now supporting the field research work of 18 young geographers.

NINTH PACIFIC SCIENCE CONGRESS

The Ninth Pacific Science Congress will be held in Bangkok, Thailand, from November 18 to December 9, 1957, under the auspices of the Government of Thailand and the Science Society of Thailand. The Academy–Research Council is the representative of the United States in the Pacific Science Association, which is responsible for the Pacific Science Congresses. The Science Society of Thailand, therefore, has invited the Academy–Research Council and, through it, the scientists and representatives of institutions in the United States to participate in the Ninth Congress.

Under the sponsorship of Unesco, the Organizing Committee is planning a special symposium on humid tropics research with special reference to climate, vegetation, and land utilization in the humid tropics. Gen-

eral symposia are also being planned on the following subjects: *1*) geology and geophysics; *2*) meteorology; *3*) oceanography; *4*) zoology; *5*) entomology; *6*) botany; *7*) conservation; *8*) museums; *9*) soil and land classification; *10*) forest resources; *11*) crop improvement; *12*) coconut problems; *13*) animal improvement; *14*) chemistry in the development of natural resources; *15*) public health and medical sciences; *16*) anthropology and social sciences; *17*) fisheries; and *18*) nutrition.

Air Marshal Muni M. Vejyant Rangsrisht is serving as President of the Ninth Congress and Dr. Charng Ratanarat as Secretary-General. Additional information regarding the Congress may be obtained from the Office of the Secretary-General of the Congress, Department of Science, Ministry of Industry, Bangkok, Thailand; or from the Pacific Science Office, Academy–Research Council, 2101 Constitution Avenue, Washington 25, D. C.

STAFF APPOINTMENTS

The Mine Advisory Committee has announced the appointment of **James H. Probus** as Executive Secretary in December 1956. Mr. Probus came to the Academy–Research Council from Pennsylvania State University where he was assistant professor of engineering research. For the past year he has served as secretary to the Committee which advises the U. S. Navy on scientific and technical matters relating to sea mine warfare.

The Division of Chemistry and Chemical Technology announces the appointment of **Clem O. Miller** as Executive Secretary of the Division effective February 1, 1957. Dr. Miller received his Ph. D. degree in chemistry from the University of Chicago in 1926. Before coming to the Academy–Research Council he was Scientific Director and President, and later Chairman of the Board, of the Kremers-Urban Company of Milwaukee.

Harry W. Hays has been appointed Director of the Toxicological Information Center by the Division of Chemistry and Chemical Technology, effective January 15. Before coming to the Academy–Research Council, Dr. Hays spent a number of years in the research department of Ciba Pharmaceutical Products, Inc., and since 1948 has been associate professor of pharmacology at Wayne State University. Dr. Hays received his Ph. D. degree in biology from Princeton University. His principal research interests have been in the fields of endocrinology, cardio-vascular physiology, and pharmacology of drugs related to allergy.

COOPERATING SOCIETIES

The following schedule of meetings of Societies cooperating with the National Academy of Sciences–National Research Council has been prepared from information supplied by the Societies. For details regarding a specific meeting, please write directly to the Society Secretary.

January		**January**	
10	American Genetic Association, *Washington, D. C.*	30–Feb. 2	American Physical Society, *New York City*
14–10	Society of Automotive Engineers, Inc., *Detroit*	**February**	
21–25	American Institute of Electrical *Engineers, New York City*	24–28	American Institute of Mining, Metallurgical and Petroleum Engineers, *New Orleans*
28-31	American Meteorological Society, *New York City*	24–28	Society of Economic Geologists, *New Orleans*
28–31	Institute of the Aeronautical Sciences, *New York City*	25–March 1	American Society of Heating and Air-Conditioning Engineers, Inc., *Chicago*

March

American Physical Society, *Philadelphia*

Institute of Mathematical Statistics, *Washington, D. C.*

1–2 American Physical Society, *Norman, Okla.*

3 Wildlife Society, *Washington, D. C.*

3–9 American Society of Photogrammetry, *Washington, D. C.*

6–8 American Congress on Surveying and Mapping, *Washington, D. C.*

7–9 Biometric Society, Eastern North American Region, *Washington, D. C.*

7–9 Optical Society of America, *New York City*

18–21 Institute of Radio Engineers, *New York City*

April

American Society of Ichthyologists and Herpetologists, *New Orleans*

1–4 American Association of Petroleum Geologists, *St. Louis*

1–4 Association of American Geographers, *Cincinnati*

1–5 Society of Economic Paleontologists and Mineralogists, *St. Louis*

7–12 American Chemical Society, *Miami*

8–12 American College of Physicians, *Boston*

8–12 American Welding Society, *Philadelphia*

11–13 American Association of Pathologists and Bacteriologists, *Washington, D. C.*

14–19 American Association of Immunologists, *Chicago*

14–19 American Physiological Society, *Chicago*

14–19 American Society of Biological Chemists, *Chicago*

15–19 American Institute of Nutrition, *Chicago*

15–19 American Society for Experimental Pathology, *Chicago*

15–19 American Society for Pharmacology and Experimental Therapeutics, *Chicago*

17–19 American Association of Anatomists, *Baltimore*

19–20 Seismological Society of America, *Los Angeles*

25–27 American Physical Society, *Washington, D. C.*

28–May 3 Society of American Bacteriologists, *Detroit*

29–May 1 American Geophysical Union, *Washington, D. C.*

29–May 1 American Oil Chemists' Society, *New Orleans*

May

Engineering Foundation, *New York City*

Operations Research Society of America, *Philadelphia*

5 American Federation for Clinical Research, *Atlantic City*

5–7 Industrial Research Institute, *Buck Hill Falls, Pa.*

5–9 American Ceramic Society, *Dallas*

6 American Society for Clinical Investigation, *Atlantic City*

7–8 Association of American Physicians, *Atlantic City*

8–10 American Surgical Association *Chicago*

8–11 American Astronomical Society, *Cambridge, Mass.*

12–16 Electrochemical Society, Inc., *Washington, D. C.*

13–17 American Psychiatric Association, *Chicago*

16–19 Society of Naval Architects and Marine Engineers, *Long Beach, Calif.*

22–23 American Iron and Steel Institute, *New York City*

23–25 Acoustical Society of America, *New York City*

June

American Dairy Science Association, *Stillwater, Okla.*

American Physical Society, *Notre Dame, Ind.*

Society for the Study of Development and Growth, *Kingston, R. I.*

3–5 American Society of Refrigerating Engineers, *Miami Beach*

3–7 American Medical Association, *New York City*

16–21 American Society for Testing Materials, *Atlantic City*

16–21 Society for Pediatric Research, *Carmel, Calif.*

17–19 American Neurological Association *Atlantic City*

17–20 American Society of Mammalogists, *Lawrence, Kans.*

17–21 American Society for Engineering Education, *Ithaca, N. Y.*

24–28 American Institute of Electrical Engineers, *Montreal, Canada*

24–27 American Society of Heating and Air-Conditioning Engineers, Inc., *Murray Bay, Canada*

August

American Astronomical Society, *Urbana, Ill.*

6–9 Poultry Science Association, *Columbia, Mo.*

19–22 American Veterinary Medical Association, *Cleveland*

August

25–29	American Phytopathological Society, *Stanford, Calif.*
25–29	American Society for Horticultural Science, *Stanford, Calif.*
25–29	American Society of Limnology and Oceanography, *Stanford, Calif.*
25–29	American Society of Plant Physiologists, *Stanford Calif.*
25–29	American Society of Plant Taxonomists, *Stanford, Calif.*
25–29	Botanical Society of America, *Stanford, Calif.*
25–29	Ecological Society of America, *Stanford, Calif.*
25–29	Genetics Society of America, *Stanford, Calif.*
25–29	Mycological Society of America, *Stanford, Calif.*
26–29	American Society of Zoologists, *Stanford, Calif.*
26–30	American Mathematical Society, *University Park, Pa.*
26–27	Mathematical Association of America, *University Park, Pa.*
28–30	American Institute of Electrical Engineers, *Pasco, Wash.*
30–Sept. 5	American Psychological Association, *New York City*

September

	American Physical Society, *Boulder, Colo.*
	Econometric Society, *Atlantic City*
2–5	American Physiological Society, *Iowa City, Iowa*
4–7	American Society for Pharmacology and Experimental Therapeutics, *Baltimore*
8–13	American Chemical Society, *New York City*
9–13	Instrument Society of America, *Cleveland*
9–13	Illuminating Engineering Society, *Atlanta*
10–13	Biometric Society, Eastern North American Region, *Atlantic City*
10–13	Institute of Mathematical Statistics, *Atlantic City*
24–26	Institute of Traffic Engineers, *Detroit*
30–Oct. 2	American Oil Chemists' Society, *Cincinnati*

October

	Engineering Foundation, *New York City*
1–4	American Roentgen Ray Society, *Washington, D. C.*
6–10	Electrochemical Society, Inc., *Buffalo*
7–10	American Academy of Pediatrics, *Chicago*
7–11	American Institute of Electrical Engineers, *Chicago*
14–18	American College of Surgeons, *Atlantic City*
14–19	American Society of Civil Engineers, *New York City*
17–19	Optical Society of America, *Columbus*
24–26	Acoustical Society of America, *Ann Arbor, Mich.*
30–Nov. 2	American Society of Parasitologists, *Philadelphia*
30–Nov. 2	American Society of Tropical Medicine and Hygiene, *Philadelphia*

November

	American Physical Society, *St. Louis*
4–6	Geological Society of America, *Atlantic City*
4–6	Mineralogical Society of America, *Atlantic City*
4–6	Paleontological Society, *Atlantic City*
4–7	American Dental Association, *Miami*
4–8	American Society for Metals, *Chicago*
6–8	American Crystallographic Association, *Pittsburgh*
10–13	Society of American Foresters, *Syracuse*
10–15	Society of Exploration Geophysicists, *Dallas*
11–15	American Public Health Association, *Cleveland*
13–16	Society of Naval Architects and Marine Engineers, *New York City*
18–22	American Society of Agronomy, *Atlanta*
18–22	Soil Science Society of America, *Atlanta*
29–30	American Society of Animal Production, *Chicago*

December

	American Physical Society, *Stanford, Calif.*
	Econometric Society, *Philadelphia*
1–6	American Society of Mechanical Engineers, *New York City*
2–5	Entomological Society of America, *Memphis*
8–11	American Institute of Chemical Engineers, *Chicago*
27–30	Society of Systematic Zoology, *Indianapolis*
28-30	American Anthropological Association, *Chicago*

RECORD OF MEETINGS

November	
1	Committee on International Exchange of persons
	Committee on Ship Steel, Project Advisory Committee SR–139
	Panel on Deterioration Prevention
	American Geological Institute, Public Education and Public Relations Committee, *Minneapolis*
	American Geological Institute, Government Relations Committee, *Minneapolis*
	American Geological Institute, Professional Relations Committee, *Minneapolis*
2	USA National Committee for the International Geophysical Year, Executive Committee
	American Geological Institute, Board of Directors, *Minneapolis*
	Subcommittee on Oncology
	Committee on Nuclear Science
5	Ad hoc Conference for the National Committee for International Institute of Refrigeration
7	Subcommittee on Fruit and Vegetable Products, *Chicago*
	Building Research Institute, Specifications Meeting
8	Committee on Revision of Mathematical Tables
	Panel on Plastics
	International Conference on Scientific Information, Planning Committee
8–9	American Geophysical Union, Pacific Northwest Regional Meeting, *Seattle*
	Fire Research Correlation Conference
8–10	National Academy of Sciences, Autumn Meeting
9	Committee on Foods, Subcommittee on Stability, *Chicago*
	Committee on Primary Records, *Philadelphia*
	Panel on Textiles
	Panel on Metals Fabrication, *New York City*
	Subcommittee on Radiobiology
	Subcommittee on International Radiation Congress
10	Committee on Nutrition Studies at Elgin State Hospital, *Elgin, Ill.*
11	International Conference on Scientific Information, Ad hoc Conference Committee
12	USA National Committee for the International Union of Physiological Sciences, *Ann Arbor, Mich.*
13	Panel on Ceramics and Refractories

November	
14	International Conference on Scientific Information, Planning Committee
	Panel on Non-Ferrous Metals
15	Conference on the 1957 Program on Pesticide Applications and Regulations
	Agricultural Research Institute
15–16	Symposium on Human Engineering, Personnel, and Training Research
16	Division of Physical Sciences, Advisory Selection Committee on Fulbright Awards
17	Pacific Science Board, Annual Meeting
	Committee on Mathematics Advisory to the Committee on International Exchange of Persons
	American Geophysical Union, Executive Committee
18	Division of Mathematics, Executive Committee
19	Symposium on Roll on and Roll off Sea Transportation
19–20	Food Protection Committee, *Nashville*
20	Maritime Cargo Transportation Conference, Board of Advisers
	Panel on Ferrous Metals
23–24	Biology Council, Panel on High School Biology Courses, *East Lansing, Mich.*
24–25	Committee on Animal Nutrition, *Chicago*
	Biology Council, Subcommittee on Publications and Instructional Materials, *East Lansing, Mich.*
25	Committee on Animal Health, *Chicago*
26	Panel on Elastomers
	Highway Research Board, Executive Committee, *Atlantic City*
27	Subcommittee on Swine Nutrition, *Chicago*
27–28	Institute of Laboratory Animal Resources, *Chicago*
28–29	Federal Construction Council, Government-Industry Conference on Procuring Paint
30	Panel on Magnetic Materials, *New York City*
	Office of Scientific Personnel, Advisory Committee
	Federal Construction Council, Task Group on Cooling Towers and Evaporative Condensers

December	
1	Committee on Prosthetics Research and Development, *Los Angeles*
3	Biology Council, Panel on Parasitism
4	Panel on Miscellaneous Materials
5	USA National Committee for the International Geophysical Year, Executive Committee
	USA National Committee for the International Geophysical Year and Earth Satellite Panel, Joint Meeting
5–6	Advisory Committee on Small-Size Sewer Pipe
5–7	Building Research Institute, Plastics Study Group, *Chicago*
6	Subcommittee on Radiation Preservation, *Lemont, Ill.*
	USA National Committee for the International Geophysical Year
7	Committee on Flame and Thermal Protective Combat Clothing, *Natick, Mass.*
	Biology Council, Committee on Educational Policies
	Federal Construction Council, Task Group on Maintenance and Operating Problems Affected by Design and Construction
8	Division of Earth Sciences, Executive Committee
	Screening Committee for Foreign Geographic Field Research Program
8–9	Conference on Undergraduate Curricula in the Biological Sciences

December	
9	National Academy of Sciences–National Research Council, Governing Board
10	Institute of Laboratory Animal Resources
11	Sub-panel on Titanium Sheet Rolling Program, *Dayton, Ohio*
12	Materials Advisory Board, Special Committee
	Federal Construction Council, Operating Committee
13	Committee on Textile Fabrics, *Natick, Mass.*
	Food Protection Committee and Liaison Panel
14	Federal Construction Council, Task Group on Working Drawings and Specifications
14–15	Committee on International Exchange of Persons
15	USA National Committee for the International Union of Biochemistry
17	Highway Research Board, Nominating Committee
	Panel on Dielectrics
	Building Research Institute, Subcommittee for Specifications Program
18	Division of Engineering and Industrial Research, Executive Committee
20	Division of Mathematics, Nominating Committee, *Cambridge, Mass.*
27	Division of Mathematics, Nominating Committee, *Rochester, N. Y.*

NEW PUBLICATIONS

American Geological Institute. *Survey of Geology-Geophysics Students in the Colleges and Universities of the United States in 1955–56, and of Available Scholarships, Fellowships, Assistantships, etc.* Washington, 1956. (Report 12.) 4 p. $0.50.

Conference Board of Associated Research Councils. Committee on International Exchange of Persons. *Meetings and Conferences of Professional Societies and Cultural Organizations to be Held in the United States from December 1956 to December 1957.* Washington, 1956. 15 p.

Conference Board of Associated Research Councils. Committee on International Exchange of Persons. *Visiting Scholars in the United States (Recipients of U.S. Government Grants under the Fulbright and Smith-Mundt Acts), Academic Year 1956–57.* Washington, 1956. 31 p.

Koehler, Charles R., *ed. Architectural Metal Curtain Wall Workshop–Conference, Reports of Five Workshops, October 15 and 16, 1956, Washington, D. C.* Washington, NAS–NRC, Building Research Institute, 1956. 75 p., illus.

National Conference on Clays and Clay Minerals, 4th, Pennsylvania State University, 1955. *Clays and Clay Minerals. Proceedings . . . Edited by Ada Swineford, Sponsored by Committee on Clay Minerals of the National Academy of Sciences-National Research Council and Pennsylvania State University.* Washington, 1956. (NAS–NRC Publication 456.) 444 p., illus. $6.00.

National Research Council. Building Research Advisory Board. *A study of the Anchorage of Exterior Frame Walls to Various Types of Foundations . . . Edited by Robert M. Dillon.* Washington, NAS–NRC, Building Research Institute, 1956. (NAS–NRC Publication 446.) 71 p. $1.50.

National Research Council. Building Research Institute. *Building Research Institute Plastics Study Group, Second Meeting. Report of the Meeting July 9–10–11, 1956.* Washington, NAS–NRC, Building Research Institute, 1956. 127 p., illus.

National Research Council. Food Protection Committee. *The Relation of Surface Activity to the Safety of Surfactants in Foods.* Washington, 1956. (NAS–NRC Publication 463.) 10 p.

National Research Council. Highway Research Board. *Concrete Control and Construction . . .* Washington, 1956. (NAS–NRC Publication 422. Highway Research Board Bulletin 132.) 34 p., illus. $0.75.

National Research Council. Highway Research Board. *Flexible Pavement Design Correlation Study . . .* Washington, 1956. (NAS–NRC Publication 423. Highway Research Board Bulletin 133.) 38 p. $0.75.

National Research Council. Highway Research Board. *Highway Engineering Training Programs for Professional and Preprofessional Employees, an Analysis.* Washington, 1957. (NAS–NRC Publication 480. Highway Research Board Special Report 24.) 20 p. $0.60.

National Research Council. Highway Research Board. *Proceedings of the Thirty-fifth Annual Meeting of the Highway Research Board, January 17–20, 1956.* Washington, 1957. (NAS–NRC Publication 426.) 840 p. $10.00.

National Research Council. Highway Research Board. *Utilization of Highway Engineering Manpower . . .* Washington, 1956. (NAS–NRC Publication 424. Highway Research Board Bulletin 134.) 101 p. $2.20.

National Research Council. Highway Research Board. *Widening and Resurfacing with Bituminous Concrete . . .* Washington, 1956. (NAS–NRC Publication 421. Highway Research Board Bulletin 131.) 46 p., illus. $0.90.

National Research Council. Library. *Cooperating Societies, National Academy of Sciences–National Research Council, Revised December 1956. Officers and Meetings.* Washington, 1956. 62 p.

Neel, J. V., and Schull, W. J. *The Effect of Exposure to the Atomic Bombs on Pregnancy Termination in Hiroshima and Nagasaki.* Washington, NAS–NRC, 1956. (NAS–NRC Publication 461.) 241 p. $2.00.

Notice of Academy Meetings

NATIONAL ACADEMY OF SCIENCES

Annual Meeting, Washington, D. C., April 22–24, 1957
Autumn Meeting, New York City, November 11–13, 1957

NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL

Governing Board, Washington, D. C., February 3, 1957
Governing Board, Washington, D. C., March 31, 1957
Governing Board, Washington, D. C., June 16, 1957

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